AGRICULTURAL MECHANIZATION, RURAL INCOME DISTRIBUTION AND UNEMPLOYMENT IN FAIZABAD DISTRICT, EAST UTTAR PRADESH

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A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL OF
THE UNIVERSITY OF FLORIDA
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA
1973

to

adj
and those many others
who were
exploited
to finance my education

ACKNOWLEDGMENTS

The author sincerely appreciates the uninterfering guidance and flexible attitude of Dr. W. W. McPherson and his assistance in arranging a field trip to India as a part of this study. Dr. B. R. Eddleman was always willing to discuss everything and has thereby continually added much to this work. Dr. M. Z. Kafoglis, by giving the author the idea of tradeoff curves, has been very helpful.

Luke Henderson, one of the wisest men of McCarty Hall, merits appreciation for the many evenings the author was enlivened by his wisdom during the course of this work. Luke also cleared up a lot of waste that was put out by McCarty Hall.

What the author learned besides the input-output coefficients from the many farmers of Faizabad does not show up in this work, but definitely deserves high appreication.

The author appreciates the many meaningful discussions he has had with Clyde Murphree, Gerd Wartenberg, Vinod Vyasulu and Sue Farberow during his stay in Gainesville. Usually unrelated to the narrow confines of the professional economist, these discussions did much to broaden the author's understanding of society and himself.

The author's apologies are expressed to Pattie and Mike and Mini and Gullu and Dabbu and Shailu and Ranju and Addu and Adit and John and Billy Wizard and Prem and Harpreet and the Wiegands and Santi and Linda and Peggy and Ramesh and

Veena and Saurabh and Raif and the people at the Suicide and Crisis Intervention Service and the members of the Union for Radical Political Economics and many other unmentioned friends, all of whose humanizing influence the author was able to counteract with the assistance of his class background and academic orientation during the course of this work. The Bench and Bar, The Red Lion, Krispy Kreme, and the mountains of West Virginia also deserve recognition for facilitating this process of humanization.

This study was financed, in part, by the Office of International Programs and the Department of Food and Resource Economics. The computing work was done at the University of Florida Computing Center.

PREFACE

The last two years, in which this dissertation was developed, was a period of considerable intellectual development for the author. He started with this project as an economist. Gradually, however, he began to appreciate that economic phenomena were not independent of other facets of society--technological, sociological, political and ideological.

It is often not recognized that the method chosen may predetermine the conclusions of an inquiry. In this case the method chosen as an economist--neoclassical economics, theory of the firm and linear programming--precluded consideration of these interdependent facets of the society. It precluded a holistic approach to the problem under consideration. Any attempt to study the sociological, political, ideological and other aspects of the problem would have started with an altogether different method, much closer to the analytical, descriptive and historical approach of Berg, Frankel and Bettleheim. Unfortunately, this realization came too late.

Thus, the author takes this opportunity to apologize to those friends of his who are disappointed in this work for its lack of a holistic approach. At the same time the author would like to thank, once again, those friends who helped him come to this realization.

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June 1973

Chairman: Dr. W. W. McPherson
Major Department: Food and Resource Economics

A regional linear programming model was constructed with five groups--agricultural laborers and four groups of farmers classified by size of farm. Transfer of labor and some mechanical inputs was allowed among groups. The objectives were to determine the effects of different levels of mechanization and alternative policies on income level, employment and personal distribution of income.

Under increasing levels of mechanization, the relationship between regional income and an equality index was estimated to have a negative slope--increases in regional incomes were accompanied by a decline in the equality index. Mechanization resulted in a reduction of employment opportunities and incomes for agricultural laborers and marginal farmers. The seasonality of employment for the agricultural laborers was also accentuated. These results indicate the possibility of some tradeoff potential between an increase in income and a reduction in the equality of income distribution.

Restricting the use of mechanical inputs by increasing their prices did not appear

to be a viable proposition because prices would have to be raised by more than 200 percent in order to become prohibitive. Higher wage rates would result in a more equal distribution of income but would not increase regional income. The reduction in the equality index due to mechanization increased as wage rates were increased.

Increased use of fertilizers would result in increased production and incomes, and would be accompanied by an increase in the equality index. This result indicates that fertilizers may offer a viable alternative to mechanization in so far as their impact on rural income distribution is concerned.

Increased availability of urban employment opportunities would result in substantial migration of agricultural laborers. It would also result in greater income per worker for those remaining in the agricultural sector. Increased multiple cropping would result in an increase in the employment opportunities and income for agricultural laborers. It would also result in a greater demand for tractors.

An agricultural income tax would result in a more equal distribution of income although an increase in mechanization would continue to result in greater inequality despite the income tax.

CHAPTER I

INTRODUCTION

The introduction of High Yielding Varieties (HYVs) of wheat, rice and millets has been a major element in the recent transformation in Indian agriculture. This "Green Revolution" brought Indian food grain production to levels of self-sufficiency in 1972 from near famine conditions in 1965-67. Food grain production almost doubled between 1966 and 1972.

The HYVs have shown considerable complementarity with other agricultural inputs--fertilizers, irrigation and mechanization. These inputs are basically either biological or mechanical in nature (Fatemi 1972:113). The biological inputs include the HYV seeds, fertilizers and irrigation.* These inputs tend to absorb labor and to increase the total output costs and revenues of farmers. The mechanical inputs on the other hand are labor-saving and tend to be neutral with respect to output and to reduce the total farm costs. Under certain conditions, however, mechanization may increase output and the demand for labor. The net effect on employment, costs and income, therefore, depends upon the particular combination of the two types of technologies.

*Barker et al. (1971:12) shows that adoption of mechanization is not as much a function of the biological inputs as it is a function of credit availability. It appears, therefore, that either form of technology could be adopted independently of the other.

Choice of Technique

The distinction between biological and mechanical inputs becomes crucial with the recognition that the biological inputs are generally neutral to scale while the mechanical inputs show increasing returns to scale, over a range of ouput greater than that now produced by a large number of farmers. For optimum use, the mechanical equipment requires a larger land area than is now held by a quite large share of farmers. The biological inputs, since they are labor intensive and complementary to land, are consistent with the existing system of small scale agriculture that has been characterized as the "Japanese model" (Johnston and Cownie 1969:573). The alternative and official approach of the government of India advocates expansion of the mechanical inputs along with the biological inputs (Government 1969:80). This approach is characterized as the "Mexican model" of dualistic farm size distribution with the increases in output and commercial sales concentrated in a small subsector of large scale, capital-intensive farm operations (Johnston and Cownie 1969:573).

The question of the appropriate technique for agriculture is inevitably tied to the overall developmental approach. A number of economists continue to believe that, for growth, the agricultural sector must release labor and increase output simultaneously. This change will, they contend, result in rural to urban migration and will keep urban wages low and facilitate industrialization (Cochrane 1969:63; Mellor and Lele 1972:1). However, as Eicher et al. (1970:6) have pointed out, the question of the agricultural sector releasing labor for the industrial sector (by increases in output per worker due to agricultural mechanization) is really academic if urban unemployment exists, and rural to urban migration continues. This condition

implies that the approach for the future should be to expand rural employment. It is therefore important to analyze the impact of agricultural mechanization on rural employment.

Agricultural Mechanization

In general there has been a great degree of concern with the fast pace of mechanization (e.g., Shivamaggi 1972:69). Frankel (1971:31), with regard to the small farmers in Punjab reports that "there is a virtually unanimous agreement that the present demand for tractors and other machinery amongst this class of cultivators is completely unjustified on economic grounds, and that it will collapse within a few years as the farmers themselves discover it to be an uneconomic proposition." Jakhade and Gadgil (1970:16) on the basis of a benefit-cost study, report that in certain cases, although tractorization may result in a net loss to the farmer, it may still be possible for him to buy a tractor and repay the loans on it. Krishna (1969:80) claims that mechanization is uneconomic but is proceeding due to political pressures.

One explanation of the rapid mechanization lies in the changes in the relative factor prices of human labor and animals versus machines as sources of power. Subsidization of mechanical inputs may have turned the relative factor prices further in favor of mechanization. Rao (1972:393) shows that, in the period 1961-69, the price of agricultural commodities and bullocks rose by about 100 percent, while the price of tractors rose by less than 50 percent. The high wages in critical periods, inspite of availability of labor, may have the same effect (Chopra 1972:121). Further, tractors and other agricultural machinery may have become status symbols and may be bought for that reason (Frankel 1971:30; Lidman 1968:5).

Another explanation of mechanization lies in the seasonal nature of agricultural operations that create large demands for labor in selected periods. If this bottleneck is broken by mechanization, although it may directly displace labor in those periods, it may allow a greater intensity of cultivation and thereby increase the total demand for labor due to the indirect effect (Gayoso 1971:7). A related matter is the timeliness of operations during the bottleneck (Chopra 1972:121) and the desire on the part of the larger farmers to escape from the dependency on agricultural labor in this crucial period (Frankel 1971:198). Disruption caused by labor could be very costly to the larger farmers in critical periods such as harvest time.

Generally, one finds a correlation between the adoption of the mechanical and biological inputs. As a result there are three simultaneous effects on employment: the complementary effects of biological inputs on labor; the direct substitution effects of mechanical inputs for labor; and the indirect effects of mechanical inputs, which may be complementary with labor. An observation is frequently made that the net effect of the biological and mechanical inputs is not labor displacing. This does not imply, as is often assumed, that mechanization does not displace labor. In the absence of mechanization, the adoption of biological inputs alone would have resulted in an increase in the labor input. Due to mechanization this increase may not have occurred, thereby actually adding to unemployment.

The problem becomes more complex with the recognition that different mechanical inputs have different effects on the use of labor and on production (Rao 1972:395). Mechanized irrigation allows much greater intensity of irrigation and cultivation, although it may displace labor in slack periods. Tractors may alleviate labor shortage in certain periods but may also add to unemployment in others. Tractors

primarily displace bullocks and may have some effect on the quality of tillage. There appears to be a consensus that tractors result in a higher cropping intensity that leads to greater production (Chopra 1972:72). Combines, reapers, and threshers displace labor directly in the critical harvest period. These machines may reduce waste caused by rains and other contingencies. Dusters and sprayers may be necessary for performing operations otherwise impossible. Weedicides and herbicides may eliminate the need for manual cultivation and thereby add to unemployment in slack period.

The approach to the study of mechanization should, therefore, start from a nonmechanized situation with adoption of biological inputs alone. In consideration of the fact that large increases in the agricultural labor force are likely, mechanization should be directed only to the displacement of labor engaged in the operations performed in the bottleneck periods. This approach would allow for greater indirect labor-complementary effects of mechanization and would also make it possible to study the tradeoff between production and unemployment if one exists.

Furthermore, mechanization creates employment in the industrial and the agribusiness sector, i.e., in manufacture, distribution and services (Scoville 1972:8). The relevant question, however, is not whether employment is created in these sectors, but what the effect on employment would have been if the capital had been put to alternative uses. If, for instance, the investment was directed to the production of bicycles, it might be expected to create very similar effects on urban employment. It is therefore questionable whether creation of this secondary employment should be attributed to agricultural mechanization. Also, the capital/labor ratio may be expected to be higher in the industrial and agribusiness sectors compared with the

agricultural sector. Thus the question of secondary employment is crucially linked with the question of alternative uses of the capital. Nevertheless, it may be desirable to study mechanization independently and assess the total impact on employment.

In relation to this issue, Johnston and Cownie (1969:577) have pointed out that the use of biological inputs and certain improved bullock implements relies heavily on the rural labor-intensive industry, while the use of sophisticated machinery relies more heavily on capital-intensive urban industry that often has a large foreign exchange component. In the former case, the multiplier effect occurs within the economy with emphasis on labor used, while in the latter case the multiplier effect often occurs in the foreign countries (Scoville 1972:13).

Rural Income Distribution

There has been considerable concern with the increasing degree of inequality in the rural income distribution as a result of the green revolution (Cleaver 1972:91; Falcon 1970:705; Frankel 1971:196; Wharton 1969). Bardhan (1970) empirically shows that the lower sections of rural populations are not sharing in the gains of the green revolution. Dandekar and Rath (1971) show that no change in the real incomes and consumption of the rural poor have occurred since the 1950's. Schluter (1971) shows that the small farmers are slower to adopt the new technology. In addition to the technology that exhibits increasing returns to scale, and therefore is unsuited for adoption by the small farmers, there are other problems with the adoption of technology which is neutral to scale.*

*Some persons have indicated a belief that the green revolution and these problems of income distribution and welfare of the rural masses are independent,

The cultivation of HYVs requires cash inputs--irrigation and fertilizers in particular. The small farmers often may not have the working capital to purchase these inputs (Frankel 1971:62; Saxena 1971:16). Their traditional capital and family labor are fixed, unshiftable and unsaleable. The cooperative and district credit programs may not provide the capital because they assess repayment capacity on the basis of land ownership (Saith and Tankha 1972b:714). Thus, the small farmer may have to borrow capital from the village money lender at rates between 24 and 48 percent per annum compared to 9 to 12 percent charged by those agencies servicing the landed class.

The organization of the small farm household activities is directed toward production for home consumption. In order to generate the finance for the purchase of cash inputs, they have to make major changes in the organization of their household activities and direct them towards production for market. This initial change itself requires finances and flexibility which may not be available (Saith and Tankha 1972a:353).

The small farmers and tenants may not have the security of contract and hence may lack the inducement to invest (Saith and Tankha 1972b:718). They do not have sufficient assets or accumulated income to withstand a crop failure and are extremely reluctant to experiment with the new technology. They are not assured

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neglecting the fact that the problems arise largely because of the new technology. For example Ladejinsky writes, "It is not the fault of the green revolution that the credit service does not serve those for whom it was originally intended, that the extension service is falling behind expectations, that the village panchayats, or councils, are essentially political rather that developmental bodies, that security of tenure is not given to the many, that rentals are exorbitant, the ceilings on land ownership are notional, that even rising wage scales are hardly sufficient to satisfy the basic essentials of the farm laborer, or that generally speaking in those conditions economic necessity and social justice of and for the village poor do not ride in tandem" (1970:766).

of timely availability of other inputs, water in particular, to which the HYVs are highly responsive. They have neither the transportation nor access to market and storage facilities that would enable them to sell their crops at the most opportune prices (Saxena 1971:16). It may not be economical for tenants to adopt HYVs as their rent is a fixed percentage of the product--usually between 50 and 67 percent--and, consequently, a large share of the additional product would go to the landowner.

Rapid adoption of HYVs by the large farmers may increase the production within a short time period. The large output may satisfy the demand (Johnston and Cownie 1969:576) and drive the prices down to make it unprofitable for the small farmers to incur the initial (lump) cost of adoption (Gayoso 1971:12).

Mechanization allows large farmers to bring larger areas under their direct control, and eliminates their need for tenants. It creates an incentive to evict tenants and convert them into hired laborers (Cleaver 1972:94). It has been empirically substantiated that the size of the land holdings of large farmers increases with mechanization (Rudra et al. 1969; Chopra 1972). This change increases the degree of inequality in the distribution of income by increasing the labor/land ratio on the nonmechanized farms (Johnston and Cownie 1969:576).

It is clear that the new technology may affect different groups within the same sector quite differently. In this case, one of its immediate results could be to increase the degree of inequality in the rural income distribution.

Further Observations

In addition to problems of income distribution within a region, there are questions regarding equity among regions. The green revolution is benefitting those

regions which are already the most developed areas. Moreover, the prospects for future extension into these latter (arid) areas are not very promising. There has been some work but very little success with the development of new varieties adapted to dry or flood areas (Cleaver 1972:92). Staub and Blase (1972) indicate that a large portion of the increase in the value of agricultural product has occurred in three states: Punjab-Haryana 40.5 percent, Uttar Pradesh 10.4 percent, and Tamilnadu 8.6 percent. These states have 49, 36, and 41 percent, respectively of their cropland irrigated. In the other states less than 27 percent of the area is irrigated; among these, six have actually lost in terms of value of their production (Staub and Blase 1972:12).

The poor peasants and dispossessed laborers will not be oblivious to the process of increasing disparities. The traditional norms of agrarian relationships based on the exchange of mutual benefits and services that have historically provided a justification for inequality between classes is breaking down, and no new justification exists to explain the process of increasing disparities in face of the slogan "Garibi Hatao".* These increasing disparities in income have led to deterioration of relations between landlords and laborers and to explosions in the form of peasant agitations (MacEwan 1971:49; Frankel 1971:40; Cleaver 1972:92). These conditions could result in a change of the entire political, social and economic superstructure of the country.

The extensive use of chemicals may lead to serious ecological problems, including

*Translated "Eradicate Poverty", this expression is the present popular slogan of the Indian Government.

those similar to the corn blight in the U.S. in 1970. India may not be able to withstand such a loss of production. The HYVs are much more susceptible to pests and diseases and require heavy use of chemicals. These chemicals may have extensive ecological costs that do not become evident for long periods of time (Cleaver 1972:99).

It has been pointed out (Johnston and Cownie 1969:576; Falcon 1970:701) that with the preoccupation of economists with the food shortages of the late sixties, an all out attempt to increase production may create a surplus situation and the consequent problem of disposal of the product of the less developed countries. With the HYVs having been developed for all major crops there is no reason to believe that export potential will rise (Cleaver 1972:97), and this lack of market could become a major problem of the seventies.

Review of Empirical Studies

Comparisons of rates of mechanization in India with those of developed countries have sometimes been used to infer that "...future increases in power must largely come from mechanization.... There is scope for much larger mechanization and a much faster pace of mechanization without detriment either to man or cattle in the matter of employment" (Venkatappiah 1972:8). Shukla (1972:52) attempted to show that mechanization has occurred mainly in states where labor/land ratios are lower than the average, and that the aggregate statistics do not show a displacement of labor. The problem, however, is not of duplicating the development process of the West which developed under drastically different factor proportions. Neither is it a matter of displacement of labor alone. The crucial question is whether the increases in employment which could have occurred with the use of new technology are

occurring, a question that such comparisons of aggregate statistics fail to answer. Two other techniques extensively used to study the employment aspects of the new technology are budgeting and analysis of variance (e.g., Singh, L. R. 1971:2; Chopra 1972:83). The results do not show a consensus. This lack of consistency, perhaps, is because of the universal failure to distinguish between the three types of effects operating upon employment that were mentioned earlier. These studies do not address themselves to the possible increases in the labor use and they do not attempt to isolate the different effects on employment.

Linear programming (LP) has also been used in this context. Both Desai (1963) and Mann (1967) used regional LP models. Their primary interest, however, was not mechanization or income distribution but the comparison of existing crop patterns with those developed by their models under different resource situations. Wills' (1970) study is more relevant to this question as it specifically analyzes the distribution of income between three groups of farmers and also considers the impact of modern inputs, although it does not isolate the effects of agricultural mechanization.

CHAPTER II

DESIGN OF STUDY

The Problem

The specific matters with which this study deals are the economic problems of agricultural mechanization. In Chapter I the likelihood that agricultural mechanization would result in a net displacement of labor if the direct labor substitution effect was not offset by the indirect labor complementary effects was discussed. If a net displacement of labor occurs on the larger mechanized farms, the per worker incomes of the agricultural labor and the smaller farmers who hire out their labor will decline when alternative employment opportunities do not exist and unemployment among them rises. The displacement could be in the form of accentuation of seasonality of employment, or it could be in the form of an increase in the lack of employment opportunities throughout the year. In the latter case, the result would be stronger pressures on migration to urban areas where there already are high levels of unemployment.

At the same time mechanization may lead to greater production, which perhaps could not be achieved with the existing human and animal resources. Thus, mechanization may add to the total production and total net income of the region. In this event there may exist a tradeoff between an increase in inequality in income distribution and an increase in net regional income (Jhunjhunwala and McPherson 1972).

Another possibility, however, is that increases in production and income obtained as a result of mechanization would also be feasible without the use of mechanical inputs. Agricultural machinery may primarily be a substitute for labor, in which case it would increase the net income on the larger farms, while resulting in a reduction of net incomes on the smaller farms.

The Objectives

As it was pointed out earlier, mechanization is a general term. It includes mechanization of tillage and transport, threshing, and irrigation, with the use of tractors, threshers, and tubewells, respectively. The impact of each of these forms of mechanization may differ. It was believed that mechanized irrigation would produce special results. Irrigation is not a mere substitute for labor because it performs an operation otherwise infeasible. The traditional well in the area is only about 15 to 20 feet deep and has a limited capacity. Tubewells are much deeper and create a much greater irrigation potential. It has been shown that the crop intensity, yields and the labor input increase with the introduction of tubewells (Misra 1968:32). Under these conditions the net impact of tubewells would be expected to increase employment and to have no adverse effects on income distribution. For this reason, mechanization of irrigation was not analyzed in the present study.

Very little research has been done on the impact of tractors and threshers. There is little evidence that the quality of work performed is improved as a result of the use of these machines. Their impact on unemployment, on the other hand, could be severe. This study focuses on these two machines. Henceforth, "mechanization" refers to threshers and tractors only. There were two objectives of this study.

The first objective was to determine the impact of mechanization, as it is occurring presently, in order to identify any tradeoffs that may exist between income distribution and aggregate amount of income.

The second objective was to estimate the effects of selected alternative government policies, that might be implemented. These policies included increased prices of mechanical inputs, an increase in the wage rate, increased use of fertilizers, urban employment possibilities, increased double cropping and an agricultural income tax.

The Study Area

The area selected for the present study was Faizabad District in East Uttar Pradesh. The area is located south of river Ghaghra in the belt of river Ganges. The selection of this area was made after consideration of many factors. Since the emphasis of the study was placed on agricultural mechanization, it was essential that the area have a "reasonable" number of tractors and threshers, and it should not be unusual in terms of the number of tractors already in use, such as the large numbers in Ludhiana and Ferozepore and the very small numbers in Azamgarh (only four tractors were reported in operation in 1970). This selection would assure a wider applicability of the results. Punjab, Gujrat and West Uttar Pradesh were ruled out because of the low labor to land ratio in comparison with many other areas of the country. Furthermore, those areas already were well researched relative to others. The familiarity of the author with the agriculture and the local dialect were additional advantages in the selection of Faizabad as the study area.

The total population of Faizabad was 1,926,631 in 1971 (Census of India 1972). More than 90 percent of the population were rural inhabitants. About 67

percent of the total area of 1,681 square miles was in cultivation. The soil in the area is light loam with some clay and sandy sections. The average rainfall normally is about 40 inches per year, mainly concentrated in the months of Asad, Savan, and Bhadon. There were no forests in the area. The main Rabi crops were wheat and gram; the main Kharif crop was paddy, and sugarcane was the main cash crop. The district had 2,758 villages with an average population of 541 persons per village in 1961. Forty-two percent of the population were workers in 1961 in contrast to only 34 percent in 1971--an indication that the dependency ratio has increased. More than 80 percent of all workers were agricultural laborers and cultivators (Census of India 1965). Faizabad, along with seven other eastern districts of Uttar Pradesh, is often called the most "backward" region of the state.

The Model

Selection of Analytical Techniques

The principal analytical tools selected for use in this study were linear programming (LP) and regression. Various applications of LP have been made under Indian conditions by Desai (1963), Wills (1970), and Singh, I. J. (1971). Theoretical aspects and assumptions of LP have been specified in Hadley (1962) and Heady and Chandler (1958). The particular modification of the LP method used here was suggested by Yaron et al. (1965). Some of the problems encountered in the use of LP, i.e., specification, sampling and aggregation errors are discussed by Sheehy and McAlexander (1965) and Stovall (1966). The representative farm approach used to construct the input-output coefficients has been analyzed by Sharples (1969).

LP was chosen in the present study because adjustments in allocation of

resources among farms as well as within farms were anticipated. Also, emphasis was on the investigation of the impact of certain governmental policies that lend themselves to analysis with LP techniques.

The objective function of the LP model used maximizes regional net income subject to given technical coefficients and constraints. This approach determines what it would pay farmers to do under the given circumstances. To the extent that the technical coefficients, constraints and objective function are empirically correct, it provides accurate estimates of what would occur under these same conditions.

Saith and Tankha (1972a:352) present a convincing argument that the household activities of the small farmer have considerable interdependence with his farm activities. In the present study the interdependences of household activities with farm activities have not been considered because of the lack of data and the research resources limitation. It was assumed, as appears to be the case, that in the periods of peak labor demands, the household activities would not conflict with the farm activities. The crucial interdependence for the present study is the availability of operating capital. It was consistently reported that the small farmers had some off-farm income, either from family members repatriating from their urban earnings or from other activities, and that it was often this source of capital that was utilized for the purchase of cash inputs. Estimates of availability of capital are reported in subsequent sections.

The prices of inputs were assumed to be fixed, except for the explicit changes made in the prices of mechanical inputs. This assumption was considered to be acceptable in view of the fact that the emphasis of the study was on agricultural

mechanization, and thus the relative price of mechanical inputs vis-a-vis the traditional inputs was the crucial consideration. For lack of data to empirically estimate demand functions for food grains, arbitrary estimates were used in the model.

The use of LP requires fixed input-output coefficients. In order, therefore, to allow for adjustments within farms in the allocation of resources among different methods of growing a crop the following procedure was adopted. Production functions for each of the five major crops were estimated by operations and months by means of regression analysis. These production functions were used to estimate the yields under different assumptions regarding the numbers and periods of operations. The estimated yields and the specified operations were used to develop budgets and the input-output coefficients for each crop used in the LP model. The model, in this manner allowed for the cultivation of the five crops by different methods. The schematic structure of the LP model is presented in Appendix A.

Structure of the Linear Programming Model

The model consisted of five groups of farmers, viz., agricultural laborers, marginal farms, small farms, intermediate farms and large farms. The only activity of the agricultural laborers was hiring out their labor services. The marginal farms were those having less than 1 acre, and the small farms had between 1 and 2.5 acres of land. The activities of these two groups consisted of nonmechanized growing and threshing of crops and the hiring out of their labor. The intermediate farms had between 2.5 and 15 acres, and the large farms had more than 15 acres of land. Their activities consisted of nonmechanized and mechanized production and threshing of crops, hiring in labor and purchase of threshers. The large farms in

addition could buy tractors and rent them out to the intermediate farms.

The model had a labor pool for each of the 12 months and a tractor transfer activity for each month to enable the renting of tractors by large farms to intermediate farms.

There were a set of constraints specific to each group. These constraints included total land, multiple cropping, labor, and operating and investment capital. Each group had to provide for the grain consumed by the bullocks it used. There were other restraints common to all groups. These included irrigation, fertilizer, bullocks and the total number of threshers and tractors that could be bought. Regional stepwise demand functions were incorporated for each of the five crops. A diagram of the linear programming model is given in Appendix A.

The Farms

The farm activities for the marginal farms consist of growing wheat, paddy, and gram. The other three groups in addition might grow peas and sugarcane. The intermediate and large farms might use either bullocks or tractors for their operations.

Wheat and paddy were the major crops in Rabi and Kharif, and often it was not possible to thresh these crops in the same month in which they were harvested. Typically, threshing continued for a couple of months after harvest (at the same time resulting in loss of part of the crop). The model included growing and threshing activities separately for these two crops. After threshing, the crop was sold.

The large farms received preference over the intermediate farms in the purchase of threshers. The activities of large farms included tractor buying and renting

activities. A series of limits were placed upon the total number of threshers and tractors that could be bought.

Gram and peas produced could be sold or could be used to satisfy the grain consumption requirements of bullocks. Gram could also be bought for feeding the bullocks. Sugarcane was grown for market and for making jaggery. Jaggery consumption constraints were not included in the model and it was assumed that all sugarcane would be sold.

In addition to owned operating capital, marginal farms and small farms might borrow capital up to 33 percent of the value of their owned land at an interest rate of 36 percent per annum. The intermediate farms and large farms could borrow the same amount at an interest rate of 18 percent.

Estimates of the amount of land available to each farm group for crop activities are given in the next chapter. No transfer of land was allowed among groups. Tenants were included with the agricultural laborers because tenancy contracts showed a wide variation in arrangements and no regional data were available regarding the extent of tenancy prevailing in the area.

Multiple cropping was restricted by requiring that a minimum amount of land be left fallow in at least one season. It was felt that the quality of land and other factors would not allow large increases in the crop intensity. Initially, multiple cropping or the crop intensity was limited to a maximum of 20 percent above that reported by the sample for each group. Subsequently, this restriction was removed.

The amount of labor available in each group was fixed. However, the intermediate farms and large farms could increase the amount of labor available to them by hiring from the labor pool. When hiring in labor, the large farms received

priority over the intermediate farms. In hiring out labor the agricultural laborers, marginal farms and small farms received priority in that order. These priorities are believed to represent the prevailing situation. The large farms have the bargaining power due to their overall domination, and the agricultural laborers have the greatest need because hiring out labor is their sole source of income. No payments in kind for labor were included. It was assumed that all labor transfers would be paid in cash at the wage rate of 2 rupees per man day.

Investment capital for threshers and tractors to the extent of one-third of the machine's value was easily available at the interest rate of 9 percent per annum from the cooperative banks or societies. It was assumed that the rest of the investment capital requirement would be saved from income earned in previous years. These assumptions are based upon the practices typically followed by the larger farmers as reported during the interviews.

The costs associated with bullocks were separated into cash expenses and grain requirements. These costs were spread over expected annual use of bullocks. When cultivation of a crop required the use of bullocks, a proportionate need for bullock grain consumption was created, and the cash costs were deducted from the net returns.

The Regional Constraints

The regional constraints described here applied to all groups of farms. The allocation among groups was affected by the model through the criterion of maximizing the regional net income. These constraints were aggregated partly because disaggregation was not considered necessary and partly because data for the distribution among groups were not available.

The irrigated area was separated into that which could be irrigated only once in Rabi and the remainder. The irrigation constraint was not applicable to paddy because of the small amount of irrigation water applied to that crop. By means of a transfer activity, the land suited for multiple irrigation might be used for single irrigation.

Fertilizer constraints were imposed for urea and for the non-nitrogenous fertilizers separately. Urea was the main fertilizer used.

The farm animals created considerable interactions in the farmers' decisions. They consumed grain stalks, some green fodder, grain and some labor (e.g., in maintenance and chopping grass). They provided power for agricultural operations, organic manure* for the fields, fuel for household cooking (dried cow dung) and milk for domestic consumption. The quality of animals on large farms differed from those on small farms, as did their feed requirements. However, the data on the distribution of bullocks among different groups of farms within the region was not available. Further, as the emphasis of the current study was on mechanization, it was not considered necessary to incorporate all these interactions into the model. The survey also indicated that tractorization had led to the displacement of bullocks and had resulted in a different distribution among groups. It was considered appropriate, therefore, to construct a regional bullock pool, as one of the regional constraints, and to let the model allocate bullocks among crops and farm groups. However, each group had to separately fulfill the grain consumption requirements of bullocks used.

*Manure refers to farm yard compost while fertilizer refers to inorganic chemicals.

The model included regional stepwise demand functions based upon aggregate regional productions of each of the five crops. It was assumed that up to 125 percent of the current levels of production of each crop could be sold at current prevailing prices. Each additional 25 percent could be sold at price reduction intervals of 20 percent up to a maximum of 200 percent of the current levels of production. This step function was incorporated into the model by subtracting from the regional net income an amount equivalent to the reduction in the price after the production exceeded 125 percent of current levels. By subtracting the amount from the regional net income the position among groups is left unchanged. If any of the stepped selling activities were included in the basis, the average selling price for that commodity was considered to be the price at which the last unit was sold.

CHAPTER III

THE DATA

The Survey

The survey was conducted in Faizabad District, East Uttar Pradesh in January and February 1972 by the author and an assistant. A stratified random sampling technique was used. The district was geographically stratified into fourteen development blocks. Within each development block an attempt was made to interview one tractor owner. In addition, a random sample of four to eight respondents was selected. Further stratification at village level for sampling purposes was not done because it would have biased the sample by the criteria used in the selection of the villages.

In the initial interviews it became clear that respondents were suspicious, apprehensive and restrained, when they were questioned regarding their land holdings, perhaps, because there was considerable speculation regarding land ceiling laws at that time. As a result, if interviews were conducted in their village, there was a distinct unwillingness on the part of the respondents to provide information. Under these conditions, it was decided that, with the exception of tractor owners, farmers would be selected at random on the roads and that they would not be questioned regarding their name, village or other matters related to ownership of land. This procedure improved the quality of the interviews substantially. A total

of 81 interviews were comple

After a preliminary analys decided to classify the farms in the sample into four groups based on the a f farms. These four groups, as indicated in Chapter II, were represented in model. The three criteria used for this classification were crop pattern hiring activity and agricultural mechanization. These characteristics c cated in Table 1. On the marginal farms a large percentage of the land w o grow wheat and paddy. Very little land was used to grow peas and sug d there was a high crop intensity--174 percent.* Ninety-two percen espondents in this group reported that they hired out their labor. The crop on small farms was more diversified and there was a lower crop intensi percent. A large number of small farms (67 percent) hired out their la the intermediate farms, diversification of the crop pattern increased and nsity declined in comparison with small farms. Labor employment shi ring out to hiring in and mechanization was reported for some operat arge farms had the lowest crop intensity, 130 percent, and on all uni hired in and some agricultural operations were mechanized.

Functions

In the initial stages of t t was found that the linear production functions required by the LP m ot allow for sufficient flexibility within a crop, i.e., flexibility in such as the type of sowing and the number of

*A crop intensity greater ercent implies multiple cropping. An intensity of 174 percent mean the land is cropped once and 74 percent is cropped twice.

Table 1.--Characteristics of Sample of Farms by Size, Faizabad District, 1971-72

Item	Group			
	Marginal	Small	Intermediate	Large
Acres in Farm: Range	0-1.0	1.0-2.5	2.5-15.0	> 15.0
Mean	0.52	1.67	5.62	23.75
Number of Respondents	15	24	33	9
	----------percent of area----------			
Total Crop Intensity	173.71	152.75	149.32	130.26
Wheat	75.37	52.98	46.01	33.49
Paddy	75.37	54.58	44.75	46.91
Gram	11.67	11.05	10.49	14.80
Peas	1.67	9.16	9.89	8.28
Sugarcane	2.96	15.05	17.44	7.75
Others	6.67	9.93	20.74	19.23
Labor:	----------percent of respondents----------			
Hired Out	92	66	5	0
No Hiring	8	17	14	0
Hired In	0	17	81	100
	----------percent of respondents----------			
Tractor or Thresher Owned	0	0	9	100

plowings. For this reason, production functions, rather than single point estimates, were estimated for each of the five crops. The independent variables were disaggregated into the different operations and, whenever feasible, into different months in which the operations were performed. A quadratic form of the production functions was selected. In the evaluation of independent variables used in the regression analysis and in the selection of coefficients for use in the LP model primarily two criteria were used--significant "t" values and logically "sensible" signs of the estimated coefficients.

It should be emphasized that these production functions were estimated from data collected during interviews with farmers, and not from actual records of the production process. A few respondents were unable to provide information with regard to a few operations and this resulted in randomly missing observations among the independent variables. The classical method of substitution of means for the missing observations was used (Haitovsky 1968; Chan and Dunn 1972). However, the mean substituted was not that of the entire population. The observations were classified into four groups according to the size of the farm, and the mean of the subgroup was substituted for the missing observation. In the estimation of these production functions, harvest labor was not included as an independent variable because it was believed *apriori* that the amount of harvest labor would be a function of the yield and not vice versa. Thus to include harvest labor would violate the principle of causality, which is central to regression analysis.

It should be emphasized that the production functions were estimated primarily for the purpose of facilitating the construction of budgets in a way that would allow greater flexibility in the production of each crop. The estimated production functions

are presented in Appendix B.

Some of the regression coefficients show increasing returns to use of certain inputs (e.g., fertilization and cultivation of paddy, see Table B-1). This indicates that some of the inputs were being used at suboptimal levels. Of particular importance are fertilizers, the supply of which was controlled by the government. In those cases where increasing returns were observed, as in any other, no extrapolation was made in the estimations of the input-output coefficients. The adjustments in case of fertilizers allowed in this study were, therefore, at suboptimal levels of usage. In this case, additional use of fertilizers to move their application per acre into the diminishing returns stage of the production function would have increased net returns. However, data obtained in the present study did not permit estimates of the relationship into the stage of diminishing returns. Another case was irrigation of sugarcane. This may have been because farmers faced an overall constraint on the availability of water.

Operations

This section includes a description of the agricultural operations. A summary of the operations requirements per acre is presented in Table 2. These figures were used in the construction of the input-output coefficients for the LP matrix.

It was assumed that all bullocks were of the same quality. This assumption was necessary because no regional data were available regarding the numbers of different quality of bullocks and their distribution among the different sizes of farms. In the present study only draught animals were included. Other animals and poultry were excluded. The use of bullocks had a cash cost of 0.50 rupees per pair of bullocks per day, required 2 man days of labor and a consumption of 0.50

Table 2.--Inputs per Acre for Plowing, Manuring, Irrigating, and Threshing

Operation	Method	Season	Rupees	Man Days	Bullock Days	Seers of Gram or Peas	Tractor Days	Thresher Days
Plow	Bullock	Rabi, Zaid	0.50	2.00	4.00	0.50	--	--
		Kharif	1.00	4.00	8.00	1.00	--	--
	Tractor[a]	Rabi, Zaid	5.55	0.25	--	--	0.125	--
		Kharif	11.10	0.50	--	--	0.250	--
Manure	Human	--	--	16.00	--	--	--	--
	Bullock	--	2.95	2.00	1.00	0.25	--	--
	Tractor and Trolley	--	2.97	0.75	--	--	0.067	--
Irrigate	Composite	Rabi, Kharif	12.12	9.85	0.76	0.09	--	--
		Zaid	24.24	19.70	1.52	0.18	--	--
Thresh	Bullock	Rabi	0.17	1.00	1.34	0.17	--	--
	Thresher	Rabi	0.54	0.125	--	--	--	0.33

[a] Includes plow, harrow and cultivator.

seer of grain, mainly grams or peas per pair of bullocks per day.

All tillage performed by bullock was assumed to be done by the traditional desi plow. Only a very few improved plows were in use. For the Kharif tillage in the months of Jeth, Asad, and Savan, the performance was approximately 50 percent lower due to the wet soil.

It was estimated that in land preparation one plowing by tractor was equivalent to two plowings by bullock, and in cultivation one operation by tractor and harrow or tractor and cultivator was equivalent to one plowing by bullock. It was also estimated that 10 percent of all mechanized tillage was performed by plow, 30 percent by harrow and 60 percent by cultivator. A single tractor tillage operation included these proportions.

During the interviews it was very difficult to ascertain the amount of farm manure applied on farms of different sizes. It was assumed that all farmers apply approximately an equivalent of four cartloads of farm manure per acre if any is applied. When manure is transported by human labor this operation requires about 16 man days per acre.

There are six important methods of irrigation. No data were available with regard to the distribution of these methods among different farm size groups. It was decided, therefore, to develop one composite budget with the six methods entered in their regional proportions.

Crops

Crop input-output coefficients were constructed for the LP model. The production functions estimated by regression were used to estimate the yields under a given set of operations. Production functions were not extrapolated beyond the

range of observations for the estimation of yields, despite the fact that increasing returns were observed in case of few inputs as explained earlier.

Coefficients did not take into account, explicitly, the difference between the HYVs and the traditional varieties of crops. The respondents failed to give the yield differentials by varieties. Most of the respondents used some HYVs, usually second or third generation seeds obtained locally. As a result, no distinction was made between the HYVs and the traditional varieties for this study.

No cash expenditure was provided for seed because farmers predominantly saved seed from the previous crop and data regarding quality, price and quantity of such seed were unreliable. No cash income was considered to be generated from the stalks of the various crops, as they were usually consumed by animals on the farm and sold infrequently. Neither expenditure nor revenue was provided for manure as it was a product of the farm and it had no cash market. It was not possible to consider the impact of weedicides and other chemicals because they were used infrequently.

In Rabi the three crops included were wheat, gram and peas. In Kharif only paddy was included. Paddy may be grown by many different methods and it constituted the major Kharif crop. In Zaid sugarcane was included.

Regional Data

The numbers of agricultural laborers, and cultivators who owned land, were available from the 1971 census of the district. Tenants and landless laborers were treated as one group. It was assumed that the large farms had one person as a manager who did not engage in any manual work. It was estimated that during the peak restrictive periods the workers would work up to 30 days in a month, and this

figure was used to determine the constraints on labor availability. The regional resource constraints by farm groups are presented in Table 3.

The land restraints by farm group were specified for the total land in cultivation. The land in the district is fairly homogeneous and one land use constraint was considered sufficient.

The estimates of the areas not allowed to be double cropped took into account the total area multiple cropped in the region and the different cropping intensities reported by different groups. For the intermediate farms and large farms additional double cropping was permitted, in view of the possible impact of mechanization, to the extent of 20 percent of the area operated.

The owned operating capital available was based upon the reported levels of cash inputs used by the sample of respondents.

The regional irrigation constraint was applied only to the Rabi crop, the period when most irrigated cultivation takes place in wheat, grams, and peas. It was assumed that all land irrigated by tanks and ponds, and 50 percent of the land irrigated by canals and Charkhi masonry wells, could be irrigated only once in Rabi. The total irrigated area in 1971-1972 was estimated to be 560,000 acres of which 179,200 acres could be irrigated only once.

The fertilizer available was estimated by projecting the trend from 1965 to 1970.* The fertilizers were separated between urea, the widely used nitrogenous fertilizer, and the remainder, aggregated in money terms. The constraints were Rs 14,625,000 for urea and Rs 7,500,000 for other fertilizers.

*For 1965 to 1970, the data were obtained from the District Officer.

Table 3.--Regional Resource Restraints by Farm Groups

Group	Size	Agricultural Workers	Farm Managers	Area Operated	Area Not Double Cropped	Operating Capital
	acre	no.	no.	acre	acre	rupees per acre
Agricultural Laborers	0.0	167,067	---	0	0	0
Marginal Farms	0.1 to 1.0	58,840	---	15,641	4,510	100
Small Farms	1.1 to 2.5	114,838	---	98,039	50,804	100
Intermediate Farms	2.6 to 15.0	164,169	---	471,651	167,827	125
Large Farms	$\geq$ 15.1	13,017	6,946	158,052	89,311	150

Sources: Agricultural Workers: Census of India (1972).
Farm Managers and Area Operated: Dandekar and Rath (1971:111) and Government (1971:116).
Area Not Double Cropped: District Statistical Officer from 1965 to 1970. Estimated figures for 1971.
Operating Capital: Survey sample.

By projecting the trend, the number of bullocks was estimated to be 395,000 in 1971-72.* Bullocks were assumed to work 30 days per month in the peak periods.

It was estimated by the author, in consultation with the district officials, that the number of tractors in use in the district in 1971-72 was about 500. However, this number was expected to increase substantially in the next few years. The local branch of the U.P. Agro-Industries Corporation had about 400 applications pending for the supply of tractors. It was reported that the demand for tractors was slackening in the Punjab, and that the allotted quota of 8,000 tractors under the International Bank for Reconstruction and Development (IBRD) loan might not be fulfilled for the lack of buyers (Statesman 1972). Under the same IBRD scheme to import 34,000 tractors in 1971-73, 15,000 have been allocated to U.P. in addition to the normal quotas. It was thus considered likely that the number of tractors might rise in the district to about 1,500 by 1973.

It was not possible to ascertain the number of threshers in the district as these machines were first introduced in 1970. During the survey it was found that most farmers owning tractors already had purchased threshers or were planning to do so before the next crop season. Since threshers can easily be energised by the tube-well motor or engine, many farmers who did not own tractors had bought threshers. The local agricultural machinery dealers estimated that threshers were being bought at three to four times the rate of the purchase of tractors. It was estimated that the number of threshers in 1972 was four times the number of tractors in the area.

*For 1956, 1961 and 1966, the data were obtained from the District Livestock Officer.

The data for the base of the stepwise demand functions are presented in Table 4. It was assumed that 125 percent of the current levels of production, as given in Table 4, could be sold at the present prices and each additional 25 percent could be sold at price intervals 20 percent lower.

Secondary Employment

The secondary employment created in the manufacture, sales and service of tractors was estimated. This employment was incorporated in the model, despite its urban nature, to assess the total impact of mechanization. Horowitz (1971) estimated the capital output and capital labor ratios for the manufacturing industry in India. In the use of these ratios it was assumed that the ratios for manufacturing industry as a whole were also valid for manufacturing tractors and threshers.

A typical 35 horsepower tractor retailed for Rs 26,000. The pretax value, after subtracting the direct and indirect taxes, would be about Rs 20,000. The corresponding figures for threshers would be Rs 1,500 and Rs 1,400, respectively. It was assumed that the pretax price was equal to value added and therefore the estimates are likely to be biased upwards. These figures were used to estimate the secondary employment created in the manufacture of tractors and threshers as given in Table 5.

To estimate the secondary employment in sales and service, seven firms dealing with agricultural equipment in Faizabad were interviewed. However, from the interviews it was not possible to estimate the employment per tractor, thresher, or tubewell. Most of the firms dealt with more than one item and usually engaged in other work such as the repair of oil extractors and flour grinding machines. Further, employment was created in the procurement of spare parts, management

Table 4.--Prices and Production of Selected Crops, Faizabad District, 1971-72

Crop	Area[a]	Average Yield[b]	Estimated Production	Sale Price[c]
	acres	maunds per acre	1,000 maunds	rupees per maund
Paddy	364,413	16.448	5,991	21.63
Wheat	232,616	33.712	7,842	29.95
Gram	93,184	12.608	1,175	25.87
Peas	104,769	13.988	1,466	25.81
Sugarcane	66,774	564.063	37,665	3.36

[a] Obtained from the District Statistical Officer.

[b] Sample averages.

[c] Obtained from the District Agricultural Marketing Officer.

Table 5.--Estimates of Secondary Employment Generated in the Manufacture of Tractors and Threshers

Item	Unit	Amount	
		Tractor	Thresher
Capital Labor Ratio: Average employment per unit of fixed and working capital used	Man years per 1,000 rupees	1/20.341	1/20.341
Capital Output Ratio: Fixed and working capital per rupee of value added	Rupees	4.4	4.4
Value Added: Pretax price	Rupees per item	20,000	1,400
Average Employment per Item	Man years	4.3262	0.3028
Average Life per Item	Years	25	10
Employment Spread over Average Life per Item	Man days per month	5.2621	0.9210

and the like, as well as in direct sales and repair of the equipment.

Data were obtained, however, for the average number of tractors, threshers and tubewells handled, and for the total employment of the firm. The employment in other subsidiary operations was omitted and, consequently, the employment estimates are likely to be biased upwards. The data are given in Table 6.

It was not possible to directly determine the employment due to any one type of equipment from these data. A regression analysis was undertaken for this purpose. The regression results are presented in Table 7.

Although there were only three degrees of freedom for the equation, this was the only method available to disaggregate the employment into its components. When the coefficients were converted to man days, the amounts of secondary employment created in sales, service and repairs were 5.625 man days per month for tractors; 2.708 man days per month for threshers; and 1.667 man days per month for tube wells. These estimates were used in the programming model.

Table 6.--Data Used to Estimate Secondary Employment Generated in Sales, Service, and Repairs of Selected Agricultural Machinery

Identification Number of Respondent	Employment, Man Years	Number Handled		
		Tractors	Threshers	Tubewells
1	14	36	24	--
2	7	--	24	72
3	12	--	--	96
4	2	--	--	24
5	15	36	36	60
6	12	--	--	150
7	12	--	24	48

Table 7.--Regression Analysis Estimation of Secondary Employment Generated in Sales, Service, and Repairs of Selected Agricultural Machinery

Variable	Item	Unit	Regression Coefficient
Dependent	Employment	Man years	--
Constant Term	--	--	0.2125
Independent:	Tractors	No.	0.2245*
	Threshers	No.	0.1080
	Tubewells	No.	0.0694*

*Significant at 80 percent level; R^2=0.70

CHAPTER IV
RESULTS

Mechanization Under Existing Conditions

The results presented in this section are from a simulation of the existing economic conditions. The crop patterns estimated by the model are compared with the reported crop pattern in Table 8. The model underestimated the area under gram, and overestimated the area under wheat, paddy, peas, and sugarcane. The model did not include miscellaneous crops, that accounted for 29 percent of the aggregate area sown. This omission was a factor in the overestimates in the area of some of the specified crops. Most of the peas were grown by intermediate farmers, although these crops were reported to be grown by the small, intermediate and large farmers. Table 8 also gives the estimated optimal crop patterns for the four groups. The differences between the existing and the optimum cropping patterns may be the result of a number of factors in addition to the omission of some crops mentioned above. Among these factors are the possibility of inaccuracies in coefficients, and resource constraints, objectives other than maximizing net income, and the fact that actions could differ from the optimum as a result of lack of technical knowledge.

To analyze the impact of agricultural mechanization under existing conditions, the numbers of agricultural machines allowed to be bought were then increased in

Table 8.--Crop Patterns: Estimated Optimal and Reported Acreage Proportions, by Groups of Farms under Existing Conditions

Item	Wheat	Paddy	Gram	Peas	Sugarcane	Total[a]
	percent of land acreage					
Marginal Farms						
Estimated	98.78	71.17	1.21	0	0	171.16
Reported[b]	75.37	75.37	11.67	1.67	2.96	173.71[c]
Small Farms						
Estimated	47.25	100.00	0	0.93	0	148.18
Reported[b]	52.98	54.58	11.05	9.16	15.05	152.75[c]
Intermediate Farms						
Estimated	28.78	38.93	0	26.86	24.28	118.85
Reported[b]	46.01	44.75	10.49	9.89	17.44	149.32[c]
Large Farms						
Estimated	34.69	70.46	38.34	0	0	143.49
Reported[b]	33.49	46.91	14.80	8.28	7.75	130.26[c]
Aggregate						
Estimated	33.49	54.37	8.18	17.16	15.40	129.05
Reported[d]	29.09	46.06	11.62	8.55	12.90	137.31[c]

[a] Greater than 100 percent represents multiple cropping.

[b] Sample averages.

[c] Includes other crops not included in the model.

[d] Obtained from District Statistical Officer.

intervals of 500 tractors and 2,000 threshers. A further run was made with no mechanical inputs to estimate the impact that has already occurred during the change from no mechanization to present levels.

Successive stages in mechanization refer to successive additions of 500 tractors and 2,000 threshers to the maximum number of these machines that could be bought.

The number of agricultural machines estimated to be bought is given in Table 9. In stage 4, when more threshers were allowed, the number of tractors declined and stabilized around 850 tractors while threshers continued to be bought until stage 6. The decline in the number of tractors indicates that threshers may be a more preferred form of mechanization than tractors. Both tractors and threshers substituted for labor in Chait when labor was restrictive. There being an upper limit on the number of threshers, up to stage 3, tractors were bought to substitute for labor in Chait. However, as the number of threshers was allowed to increase, it would pay the farmers to use threshers rather than tractors as a substitute for labor in Chait, because threshers are much cheaper than tractors.

The hiring of agricultural laborers declined up to stage 3 and then stabilized around 31 million man days. A similar reduction in employment of marginal and small farmers was estimated despite increasing secondary employment. These results are shown in Table 10. The total reduction in employment was estimated to be about six million man days, after accounting for 470,000 man days of secondary employment generated. It is interesting to note that the number of threshers that were bought continued to increase beyond stage 3 when the hiring of labor had stabilized. This change occurred after stage 3 because the production continued to shift from other crops into wheat which may be threshed mechanically (See Table 13).

Table 9.--Estimated Numbers of Tractors and Threshers Purchased at Different Stages of Mechanization

Stage	Tractors	Threshers
	number	
1	0[a]	0[a]
2[b]	500[a]	2,000[a]
3	1,000[a]	4,000[a]
4	859	6,000[a]
5	821	8,000[a]
6	852	8,581

[a] These were the maximum number of the machines allowed to be bought at each respective stage.

[b] Stage 2 represents the estimated current number of tractors and threshers in the area.

Table 10.--Labor Hiring Activity by Groups of Farms Estimated at Different Stages of Mechanization under Existing Conditions

Item	Stage of Mechanization						Change from Stage 1 to Stage 6
	1	2	3	4	5	6	
	----------million man days----------						percent
Labor Hired Out by:							
Agricultural Laborers	35.04	33.04	31.31	31.28	31.35	31.50	-10.10
Marginal Farmers	6.66	5.02	5.71	5.27	5.88	5.28	-20.72
Small Farms	4.22	1.68	2.96	3.00	3.07	3.19	-24.40
Labor Hired In by:							
Intermediate Farmers	17.42	17.73	19.12	21.56	21.66	21.75	+24.86
Large Farmers	28.50	21.86	20.56	17.62	17.59	19.25	-35.96
Secondary Employment	0	0.15	0.30	0.37	0.45	0.47	----
Total Labor Hired	45.92	39.74	39.98	39.55	40.30	39.97	-12.96

This shift did not result in a displacement of labor.

As mechanization increased, the intermediate farmers employed more labor and the large farmers employed less labor. The estimates show that seasonality of employment for agricultural laborers was also accentuated by mechanization.* Figure 1 indicates that in Baisakh, Bhadon, and Poos no agricultural employment was available to the agricultural labor after mechanization; in Asad and Savan these opportunities were substantially reduced. An increase in employment opportunities occurred only in Katik. After mechanization, it was estimated that the agricultural labor might find itself completely unemployed in four months, while before mechanization this condition existed in only one month (Fagun).

As a result of the reduction in employment, the income per agricultural laborer declined from Rs 420 to Rs 378 per year. Similar declines occurred for the marginal farmers, while incomes in the other three groups were increased. These changes are shown in Table 11. It is interesting to note that most of the changes in incomes occurred between stage 1 and stage 3 for the three smaller groups. Between stage 3 and stage 6 the main change occurred in the form of an increase of incomes for the intermediate and large farmers due to greater cultivation of wheat made possible by threshing. The data on employment shown in Table 10, also indicate that most of the displacement of labor occurred between stage 1 and stage 3.

The current annual food grain consumption of agricultural laborers was estimated at 12.93 maunds per agricultural worker (Dandekar and Rath 1971:29). This

*Mechanization here refers to a movement from stage 1 to stage 6.

Figure 1.--Changes in Labor Hired Out by Agricultural Laborers as a Result of Mechanization from Stage 1 to Stage 6 under Existing Conditions

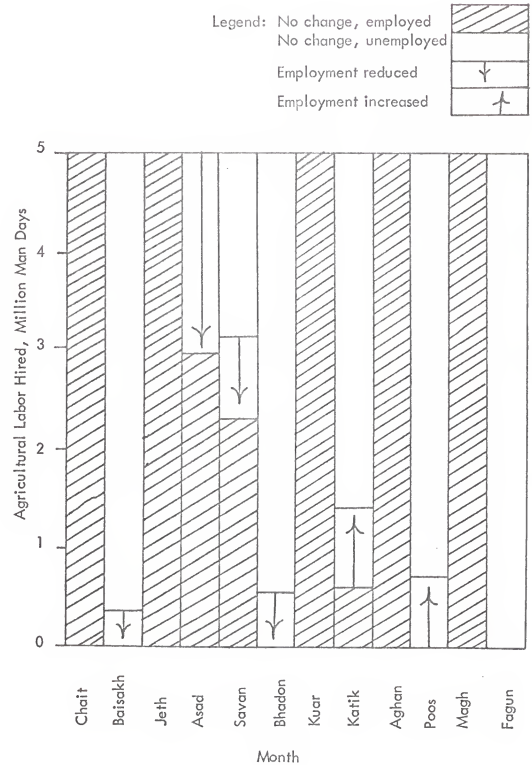


Table 11.--Estimated Income per Agricultural Worker by Farm Groups at Different Stages of Mechanization under Existing Conditions

Group	Stage of Mechanization						Change from Stage 1 to Stage 6
	1	2	3	4	5	6	
	Rupees						percent
Agricultural Labor	420	396	375	375	376	378	-10.00
Marginal Farms	606	544	517	519	519	520	-14.19
Small Farms	632	862	880	852	833	828	+31.01
Intermediate Farms	2,765	2,705	2,911	2,926	2,971	2,980	+ 7.78
Large Farms	7,973	8,646	8,413	8,853	8,896	8,809	+10.49
Mean	1,421	1,455	1,509	1,518	1,530	1,531	+ 7.74

could be fulfilled with an annual income of Rs 333 per agricultural worker.* Thus even after the decline in net income of agricultural laborers from Rs 420 to Rs 378 they could fulfill their current levels of food grain consumption. However, the minimum nutritional annual food grain requirement has been estimated at 15.97 maunds valued at Rs 412 per agricultural worker. The agricultural laborers had available these levels of income prior to mechanization, but after mechanization their incomes dropped below these levels. The other four groups would have income above these levels.

Table 12 shows that the estimated rural income distribution among different groups would become more unequal as a result of mechanization. The movement from stage 1 of no mechanization to the existing levels of mechanization of stage 2 was accompanied by an increase of 2.45 percent in the rural income, and a negligible decline in the equality index.** The movement to higher stages of mechanization was accompanied with a greater decline in the equality index, and an additional increase in income of 3.59 percent, 0.77 percent, 0.76 percent and 0.12 percent respectively, in the successive stages of mechanization. The largest changes occurred in the increase in the percentage of income received by small farmers and a decrease in the percentage of income received by agricultural laborers. The total income of the region increased by about 8 percent due to mechanization. The relationship between the equality index and total income is shown in Figure 2. The relationship is negative, which indicates that agricultural mechanization alone is estimated to result in greater inequality in rural income

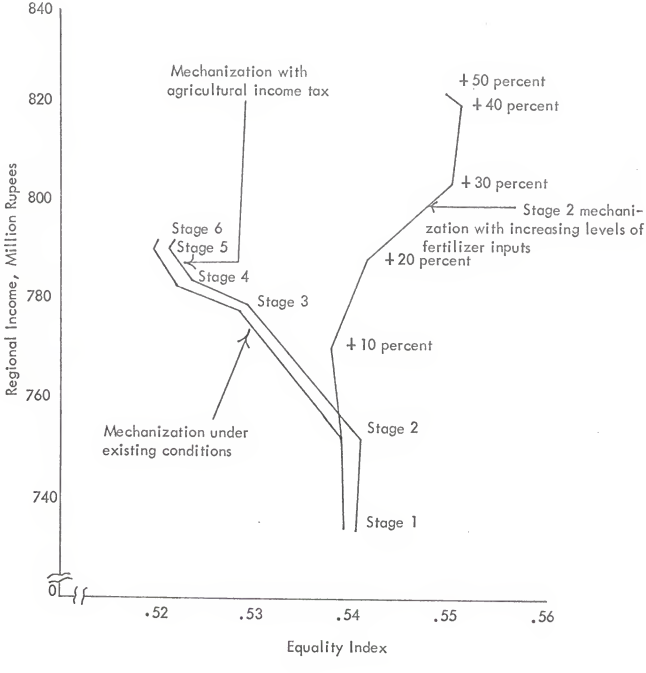
*Based on average sale price of Rs 25.79 per maund for paddy and wheat.

**The construction of the equality index is explained in Appendix C.

Table 12.--Estimated Rural Income Distribution Among Farm Groups at Different Stages of Mechanization under Existing Conditions

Group	Stage of Mechanization 1	2	3	4	5	6	Change from Stage 1 to Stage 6
	----------income, million rupees----------						
Agricultural Labor	70.2	66.2	62.7	62.7	62.9	63.1	- 7.1
Marginal Farms	35.2	31.6	30.0	30.1	30.1	30.2	- 5.0
Small Farms	72.0	98.4	100.3	97.2	95.1	94.5	+22.5
Intermediate Farms	453.1	443.5	476.8	479.9	487.3	489.1	+36.0
Large Farms	103.6	112.3	109.2	115.0	115.6	115.1	+11.5
Total	734.1	752.0	779.0	784.9	791.0	792.0	+57.9
	----------percent of income----------						
Agricultural Labor	9.56	8.80	8.05	7.99	7.95	7.97	- 1.59
Marginal Farms	4.79	4.20	3.85	3.84	3.81	3.81	- 0.98
Small Farms	9.81	13.08	12.87	12.38	12.02	11.93	+ 2.12
Intermediate Farms	61.73	58.98	61.21	61.14	61.60	61.76	+ 0.03
Large Farms	14.11	14.94	14.02	14.65	14.62	14.53	+ 0.35
Total	100.0	100.0	100.0	100.0	100.0	100.0	+ 7.90
Equality Index	.5389	.5387	.5276	.5219	.5194	.5198	------

Figure 2.--Relationship Between Estimated Regional Income and the Equality Index under Specified Levels of Mechanization, Fertilizer Inputs and an Income Tax, Faizabad District



distribution.

The total production of different crops and their prices at different stages of mechanization, as indicated by the step demand function, are shown in Table 13. Production of wheat increased by 45 percent, despite a 20 percent decline in its price. The decline in the production of paddy, gram and peas was about 10 percent for each crop. Since mechanical threshing was only possible in the case of wheat it was to be expected that production of wheat would increase at the expense of other crops with increased use of threshers. An analysis of the restrictive resources shows that land and fertilizer are restrictive at all stages of mechanization while capital and irrigated land are not. Bullocks were restrictive in Baisakh, Jeth, and Asad when paddy is sown at all stages of mechanization. With the increasing cultivation of wheat the bullocks also become restrictive in Kuar and Katik when wheat is sown, and with the increased use of mechanical threshing of wheat bullocks cease to be restrictive in Chait.

Prices of Mechanical Inputs

At existing levels of mechanization (500 tractors and 2,000 threshers), there was a substantial demand for more threshers and tractors. The shadow prices were Rs 14,504 for each additional tractor and Rs 1,204 for each additional thresher. These dual prices indicate that each additional machine would add the respective amount to the regional net income. In other words, unless the costs associated with these inputs were raised by more than these amounts, demand for agricultural machinery would persist.

The annual fixed cost under existing prices was Rs 5,183 for tractors and Rs 509 for threshers. In order, therefore, to restrict the use of these machines at

Table 13.--Estimated Production and Prices of Crops at Different Stages of Mechanization under Existing Conditions

Crop	Stage of Mechanization 1	2	3	4	5	6	Change from Stage 1 to Stage 6
	----------production, million maunds----------						percent
Wheat	7.88	9.11	10.54	11.05	11.27	11.44	+45.18
Paddy	10.09	9.49	9.18	8.98	8.98	8.98	- 11.00
Gram	2.04	2.05	2.05	2.05	2.05	1.76	- 13.73
Peas	1.76	1.78	1.78	1.54	1.54	1.60	- 9.09
Sugarcane	65.91	65.91	65.91	65.91	65.91	65.91	0
	----------price,[a] rupees per maund----------						percent
Wheat	29.95	23.97	23.97	23.97	23.97	23.97	-20.00
Paddy	12.99	12.99	12.99	17.31	17.31	17.31	+20.00
Gram	15.51	15.51	15.51	15.51	15.51	20.69	+20.00
Peas	25.81	25.81	25.81	25.81	25.81	25.81	0
Sugarcane	2.00	2.00	2.00	2.00	2.00	2.00	0

[a] Derived from the step demand function.

current levels the prices would have to be raised by 280 percent* for tractors and 237 percent for threshers. If tractors sold at the price of Rs 98,800 and threshers at Rs 5,055 one might expect that they would not be bought. These prices are very high, and therefore, restricting the use of mechanical inputs by increasing their prices does not appear to be a viable proposition.

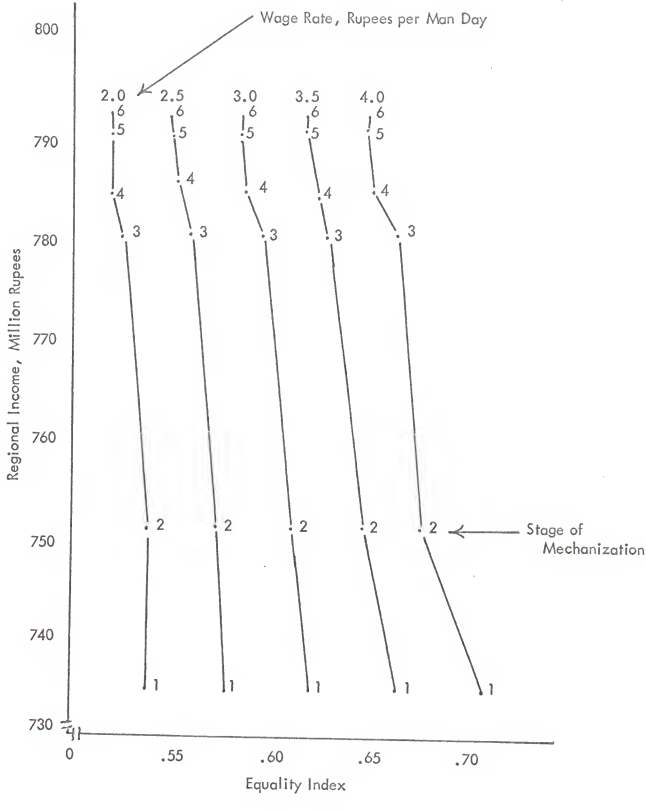
Wage Rate

The prevailing wage rate for agricultural labor in the area was 2 rupees per man day. A change in the wage rate would not change the regional income, because payments made by one group would be received by another, while the regional income would remain constant. However, a change in the wage rate would change the distribution of income in the region. Those who hire out their labor--the agricultural laborers, marginal farmers and small farmers--would experience an increase in their incomes, while those who hire in labor--the intermediate farmers and large farmers would experience a decline in their incomes. The impact of changes in the wage rate is shown in Figure 3. An increase in the wage rate would shift the relationship between regional income and equality index to the right, resulting in greater equality for any given regional income.

It is interesting to observe that the rightward shift was accompanied with an increase in the negative slope of the relationship. At lower stages of mechanization greater hiring of labor was carried out and consequently there was a greater increase in the equality index. At higher stages of mechanization less labor was hired and, consequently, there was a smaller increase in the equality index. The

*The tractor implements are manufactured by a large number of small producers that are free of any government control. It is, therefore, assumed that restricted use of tractors and accompanying implements would have to be brought about by an increase in the price of tractors alone.

Figure 3.--Relationship Between Regional Income and Equality Index at Different Stages of Mechanization and Different Wage Rates



increasing negative slope implies that at higher wage rates mechanization would result in greater inequality, although the wage rate itself would result in greater equality in the distribution of income.

Increased Use of Fertilizers

Earlier it was indicated that fertilizers were a restrictive resource at all stages of mechanization. This indicated that increased use of fertilizers would also result in an increase in regional income. In order to analyze the impact of fertilizers, maximum limits were imposed upon mechanization at current levels, and the availability of fertilizers was increased in successive intervals of 10 percent of current levels of fertilizer use. Since the production and pricing of fertilizers was closely controlled by the government, such changes in uses of fertilizers may be feasible.

The results are shown in Table 14. With an increase in fertilizer use of about 50 percent of the current level, the regional income increased by 70 million rupees, the small farmers and intermediate farmers accounted for most of the increase. There was a small reduction in the incomes of large farmers, because they could not use fertilizers as benefically as others could. The incomes of agricultural laborers remained unchanged although their share in the regional income declined by 0.78 percent due to an increase in the regional income. The equality index showed an increasing trend. The relationship between regional income and equality index with increased levels of fertilizer use was shown previously in Figure 2. The relationship is positive and thus indicates that an increase in fertilizer use would be accompanied with both an increase in regional income and an increase in equality. Whereas, mechanization would result in a higher

Table 14.--Estimated Rural Income Distribution at Different Levels of Fertilizer Use[a]

Group	Level of Fertilizer Use: Present	+10 percent	+20 percent	+30 percent	+40 percent	+50 percent	Change from Present to +50 percent
	----------income, million rupees----------						percent
Agricultural Laborers	66.2	67.1	71.9	72.9	66.5	66.0	- 0.2
Marginal Farmers	31.6	31.6	33.0	34.4	35.1	35.1	+ 3.5
Small Farmers	98.4	98.7	92.2	104.9	127.8	127.9	+29.5
Intermediate Farmers	443.5	463.9	488.6	489.5	485.9	488.3	+44.8
Large Farmers	112.3	110.0	103.5	102.6	105.4	105.4	- 6.9
Total	752.0	771.3	789.2	804.3	820.7	822.7	+70.7
	----------percent of income----------						percent
Agricultural Laborers	8.80	8.70	9.11	9.06	8.10	8.02	- 0.78
Marginal Farmers	4.20	4.10	4.19	4.28	4.28	4.27	+ 0.07
Small Farmers	13.08	12.80	11.68	13.04	15.57	15.55	+ 2.47
Intermediate Farmers	58.98	60.15	61.91	60.86	59.21	59.35	+ 0.37
Large Farmers	14.94	14.25	13.12	12.76	12.84	12.81	- 2.13
Total	100.0	100.0	100.0	100.0	100.0	100.0	+ 9.40
Equality Index	.5389	.5373	.5411	.5499	.5506	.5495	------

[a] Mechanization was held at the present level.

income with a reduction in the equality of distribution. An increase in use of fertilizers by 50 percent over present rates would result in an increase in net regional income of 70.7 million rupees--30.7 million rupees greater than that which would result from a movement of mechanization from stage 2 to stage 6.

With an increased use of fertilizers the shadow price of tractors would increase from Rs 14,504 to Rs 20,152, and the shadow price of threshers increased from Rs 1,204 to Rs 7,257. Thus an increase in the fertilizers would be accompanied by an increase in the demand for agricultural mechanization. As a result of mechanization the shadow price of urea declined from Rs 4.87 to Rs 3.02 but the shadow price of other fertilizers increased from Rs 0.69 to Rs 6.10, indicating a greater overall demand for fertilizers. Thus there is complementarity between the use of fertilizers and the demand for mechanization and vice versa. If both were adopted simultaneously the net impact on regional net income would be greater than either of the policies alone. An increase in the use of fertilizers would tend to offset the adverse effects of mechanization on employment. The net effects of simultaneous increases in mechanization and fertilizers on employment and income distribution would, therefore, lie somewhere between the results estimated for the adoption of each of the inputs separately.

Urban Employment

In order to determine the potential effects of rural to urban migration, urban employment opportunities were permitted to enter the model at different wage rates. Urban employment was considered to be year-round employment. The results are shown in Table 15. No migration was estimated to occur at wage rates below Rs 391 per year or Rs 32.60 per month. As the wage rate was increased,

Table 15.--Estimated Effects of Urban Employment Opportunities on Rural to Urban Migration, Agricultural and Urban Incomes, and Mechanization

Annual Urban Wage Rate per Worker	Rural to Urban Migration	Agricultural Income	Urban Income	Mechanization	
				Tractors	Threshers
rupees	no. workers	----million rupees----		-----number------	
360	0	791	0	852	8,581
450	20,150	782	9	544	8,780
540	43,345	769	23	1,191	8,850
630	122,532	715	77	1,020	8,634
720	144,618	689	104	1,355	8,289

larger numbers of agricultural laborers would likely seek urban employment. At a wage rate of Rs 720 per year, which was lower than the per capita income of the nation, about 145,000 agricultural laborers were estimated to seek urban employment. This constituted 28 percent of the total agricultural labor. Urban migration was also estimated to result in a greater demand for agricultural mechanization, particularly for tractors which substitute for labor in the most restrictive periods. The agricultural income of the region declined from 791 million rupees to 689 million rupees.

The effect of urban migration of agricultural laborers on different farm groups is shown in Table 16. The incomes of the agricultural laborers, who remain in their agricultural occupation, increased from Rs 377 per worker per annum to Rs 579. The incomes of the marginal farmers also increased by about 50 percent. On the other hand, the incomes of the small farmers would decline by about 23 percent, that of intermediate farmers by 6 percent, and large farmers by 13 percent. The average income per agricultural worker would increase by 21 percent. These figures demonstrate the equalizing and income improving impact of migration of agricultural laborers--the decline in incomes of larger farmers is accompanied with an increase in incomes of agricultural laborers and marginal farmers. These results further illustrate the need for nonfarm employment opportunities if mechanization is to occur with a minimum of social disruption.

Double Cropping

An attempt was made to estimate the impact of allowing an increase in multiple cropping--the impact of land improvement schemes which may allow greater areas of land to be multiple cropped.

Table 16.--Estimated Effect of Urban Employment Opportunities on Income per Agricultural Worker by Farm Groups

Group	Urban Wage Rate, Rupees per Year					Change from Rs 360 to Rs 720
	360	450	540	630	720	
	----------rupees per worker--------					percent
Agricultural Labor	377	394	404	516	579	+53.58
Marginal Farms	509	526	509	696	764	+50.10
Small Farms	818	792	783	714	626	- 23.47
Intermediate Farms	2,972	2,966	2,978	2,814	2,802	- 5.72
Large Farms	8,757	8,834	8,450	8,220	7,605	- 13.17
Mean	1,523	1,570	1,620	1,808	1,845	+21.14

It was estimated that such a scheme would increase the employment available to agricultural labor from 31 million man days to 34 million man days. Their incomes were estimated to increase from Rs 378 per worker to Rs 411 per worker, an increase of about 9 percent. It is interesting to recall that the agricultural laborers could meet their minimum nutritional foodgrain requirements at annual income of Rs 412 per worker. Thus the increase in multiple cropping would allow the agricultural laborers to meet their minimum nutritional foodgrain requirements. The average income per worker for the region increased from Rs 1,531 to Rs 1,541.

The increase in employment occurred along with a greater demand for tractors. The number of tractors bought was estimated to increase from 852 to 1,191, and the number of threshers bought was estimated to decrease slightly from 8,581 to 8,433. This change was to be expected. With increased possibilities of multiple cropping, the employment of labor increased, but that was not sufficient to utilize the opportunities available, hence the need to substitute tractors for labor.

Agricultural Income Tax

In 1972 there was no taxation of agricultural income, although such a measure had been contemplated. The taxation of nonagricultural income was at the rate of 5 percent beyond an income of Rs 5,000 per individual, up to Rs 10,000 per year. If the same rates were applied to agricultural income only the large farmers would be taxed--their income per worker was around Rs 8,000 year.

The LP model was modified to tax the large farmers at these rates. This did not result in any change in the enterprise combination for any farm group. The incomes per workers of all groups other than large farmers, and the employment

opportunities remained unchanged. The distribution of income, with the agricultural income tax imposed, is shown in Table 17. By comparing these results, with those given in Table 12, it can be seen that an agricultural income tax would result in an increase in the equality index at all stages of mechanization. This relationship was shown previously in Figure 2. It can be seen that the agricultural income tax would shift the relationship to the right, or towards a more equal distribution without changing the slope of the relationship. It was estimated that the application of current rates of the nonagricultural income tax to agriculture would result in a revenue of approximately 2.5 million rupees per year for the government.

Table 17.--Estimated Rural Income Distribution at Different Stages of Mechanization with an Agricultural Income Tax

Group or Item	Stage of Mechanization 1	2	3	4	5	6	Change from Stage 1 to Stage 6
	----------percent of income----------						percent
Agricultural Labor	9.58	8.83	8.07	8.02	7.97	8.00	- 1.58
Marginal Farms	4.80	4.21	3.86	3.86	3.82	3.82	- 0.98
Small Farms	9.84	13.16	12.90	12.43	12.06	11.97	+ 2.13
Intermediate Farms	61.89	59.14	61.39	61.29	61.80	61.99	+ 0.10
Large Farms	13.88	14.67	13.78	14.40	14.35	14.21	+ 0.33
Total	100.0	100.0	100.0	100.0	100.0	100.0	+ 7.69
Equality Index	.5403	.5404	.5291	.5236	.5210	.5214	------
	----------million rupees----------						percent
Total Disposable Income	732.31	750.29	77.75	781.75	788.51	788.65	+ 7.69
Income Tax	2.43	2.36	2.22	3.25	2.53	2.48	+ 0.82
Regional Income	734.74	752.65	779.97	785.00	791.04	791.13	+ 7.69

CHAPTER V
SUMMARY

Summary of the Present Study

The introduction of HYVs of wheat, rice and millets has been a major element in the recent transformation of Indian agriculture. The HYVs have shown considerable complementarity with other agricultural inputs such as fertilizers and irrigation. Mechanization has often accompanied the introduction of these other inputs. These inputs may have different effects, direct and indirect, upon employment, incomes and production. There has been considerable concern with the fast pace of agricultural mechanization, and there has been considerable confusion between its direct labor substituting effects and its indirect labor complementary effects.

The first objective of this study was to determine the impact of mechanization, as it has occurred recently, on the regional aggregates of rural employment, income distribution and production. The second objective was to estimate the effects of selected alternative government policies, that might be implemented. These policies included an increase in prices of mechanical inputs, an increase in wage rates, an increase in use of fertilizers, an expansion of urban employment possibilities, an increase in double cropping and an agricultural income tax.

The area selected for study was Faizabad District in East Uttar Pradesh. The

regional LP model consisted of five farm groups--agricultural laborers and four sizes of farms. The model allowed transfer of labor and mechanical inputs among groups. Those resources common to the region were allocated among groups in a way that would maximize the regional net income--the objective function of the model. A survey was conducted in 1972 to collect the data for the model.

Under increasing levels of mechanization, the relationship between regional income and an equality index was estimated to have a negative slope--increases in regional incomes were accompanied by a decline in the equality index. Mechanization resulted in reduction of employment opportunities for the agricultural laborers and a decline in their incomes. The seasonality of employment for the agricultural laborers was also accentuated. As the level of mechanization was increased the rural income distribution became more uneven and the agricultural laborers and marginal farmers experienced a decline in their absolute as well as relative incomes. These results indicate the possibility of some tradeoff potential between an increase in the amount of income and a decrease in equality of income distribution.

Restricting the use of mechanical inputs by increasing their prices did not appear to be a viable proposition because prices would have to be raised by more than 200 percent in order to become prohibitive. Higher wage rates would result in a more equal distribution of income but would not increase regional income. The reduction in the equality index due to mechanization increased as wage rates were increased.

Increased use of fertilizers would result in increased production and incomes, and would be accompanied by an increase in the equality index. This result

indicates that fertilizers may offer a viable alternative to mechanization in so far as their impact on rural income distribution is concerned.

Increased availability of urban employment opportunities would result in substantial migration of agricultural laborers. It would also result in greater income per worker for those remaining in the agricultural sector. Increased multiple cropping would result in an increase in the employment opportunities and income for agricultural laborers. It would also result in a greater demand for tractors.

An agricultural income tax would result in a more equal distribution of income although increases in mechanization would continue to result in greater inequality despite the income tax.

Suggestions for Future Research

Specifically with regard to this study, it might be worthwhile to determine optimum levels of fertilizer usage to provide additional guidelines for a fertilizer program, since fertilizers appear to have the most favorable effects on income and income distribution. There are broader and more fundamental issues, however, that are more important.

A number of empirical investigations of the Green Revolution have already been made by economists. However, this mass of data needs to be put into perspective by taking a holistic (not interdisciplinary) approach. Especially for India, a nation that has undergone substantial political changes within the last three decades, there is no reason to take the capitalistic system as given and proceed to investigate adjustments within this system as the neoclassical economic theory implicity assumes. Future research would be much more meaningful if the

political, sociological, economic and ideological aspects were simultaneously analysed and then an attempt was made to maximize the total welfare of the society in the long run. Short-run neoclassical approaches to the problems are useful in their own right, but they could be much more meaningful if these inter-dependencies were taken into account.

Some of the questions that need to be asked are as follows. What is the impact of the use of market inputs on the existing village social relations? What are the effects of the HYV transformation on those who refuse to use these inputs, if there are any such farmers? Are there any alternative institutional arrangements through which the gains of the new technology might be obtained without the use of a market system? What is the nature of changes in social stratification that are a result of these economic changes? Does the transformation lead to destruction of the traditional jajmani* system, and what are its implications for those who depended greatly upon such transfers of goods and services? How do the agricultural laborers perceive increasing inequality? Under what conditions and how does this transformation aid in the organization, politicization, and greater direct participation of the rural poor in the democratic processes? Are increasing imports of agricultural inputs and technology resulting in a political dependence of India on other nations; or are these only a substitute for imports of final products? Is there an alternative ideological system which may allow the gains of the new technology to be obtained along with much greater equality in the distribution of income? Out of attempts to answer these questions one may obtain new insights into these problems.

*Jajmani system involves reciprocal exchanges of good and services, usually between the landed class and the rural craftsmen.

GLOSSARY

1 rupee = 0.13 U. S. Dollars (1971-72)

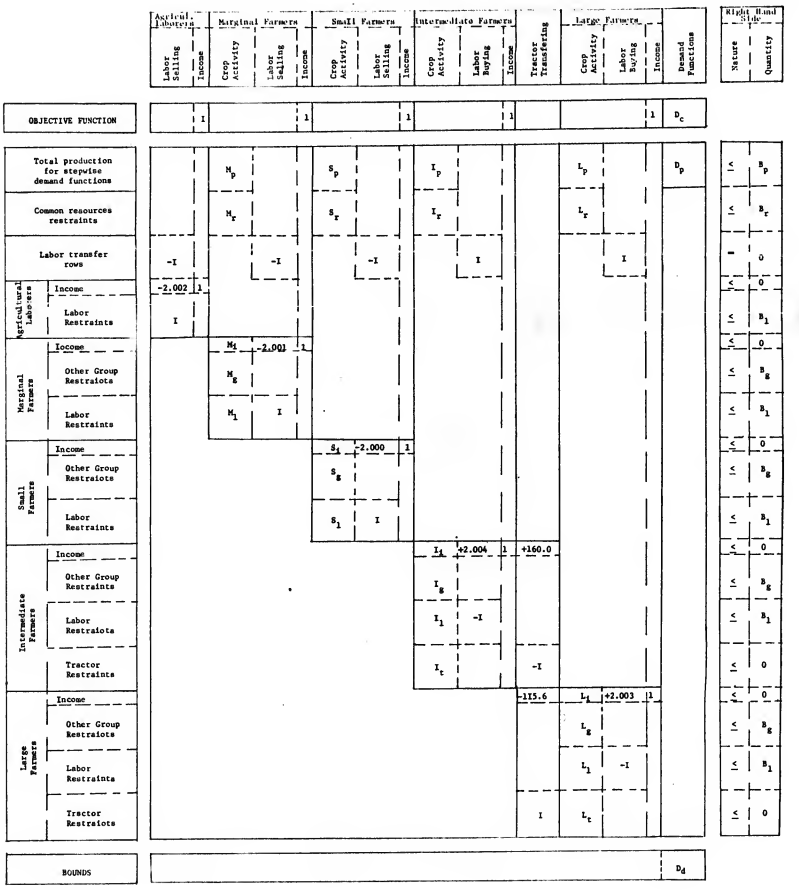
1 maund = 40 seer = 82.29 pounds = 0.373 quintals

Chait	March
Baisakh	April
Jeth	May
Asad	June
Savon	July
Bhadon	August
Kuar	September
Katik	October
Aghan	November
Poos	December
Magh	January
Fagun	February
Kharif	May to October
Rabi	September to March
Zaid	February to June

APPENDICES

APPENDIX A

SCHEMATIC STRUCTURE OF THE LINEAR PROGRAMMING MODEL


Agricul. Laborers
Marginal Farmers
Small Farmers
Intermediate Farmers
Large Farmers
Tractor Transferring
Demand Functions
Right Hand Side
Nature
Quantity
Labor Selling
Income
Crop Activity
Labor Selling
Income
Crop Activity
Labor Selling
Income
Crop Activity
Labor Buying
Income
Crop Activity
Labor Buying
Income
OBJECTIVE FUNCTION
Total production for stepwise demand functions
Common resources restraints
Labor transfer rows
Agricultural Laborers
Income
Labor Restraints
Marginal Farmers
Income
Other Group Restraints
Labor Restraints
Small Farmers
Income
Other Group Restraints
Labor Restraints
Intermediate Farmers
Income
Other Group Restraints
Labor Restraints
Tractor Restraints
Large Farmers
Income
Other Group Restraints
Labor Restraints
Tractor Restraints
BOUNDS
-2.002
-2.001
-2.000
+2.004
+160.0
-115.6
+2.003

Notes to Accompany Schematic Structure of the Linear Programming Model, Faizabad District

B--Right-hand side values. For the stepwise demand functions (B_p) they contain the amount of each crop that may be sold at existing prices.

D--Activity coefficients for the stepwise demand functions. Each of these activities allows production in the excess of B_p but subtracts a certain amount from the objective function (D_c). These steps have upper bounds specified by D_d.

I--Unaccompanied with a subscript it specifies an identity matrix, 12x12, for transfer activities in each of the 12 months. Accompanied with a subscript it denotes the coefficients for intermediate farmers' crop activities.

L--Coefficients for large farmers' crop activities.

M--Coefficients for marginal farmers' crop activities.

S--Coefficients for small farmers' crop activities.

c--Coefficients for the objective function. These subtract specified amounts from the regional income when production of any crop exceeds the specified amount.

d--Upper bounds for each step of the stepwise demand function for each crop.

g--Coefficients for those resources that are fixed at the groups level.

i--The costs and returns from the crop growing and selling activities of the four farm groups. The group income is transferred to the regional income by an income transfer activity for each group. Thus these coefficients indirectly go into the objective function.

l--The labor requirements for the crop activities.

p--The total production for each of the five crops for the demand function.

r--The coefficients for those resources common to all groups and fixed at the regional level.

Note: The input-output coefficients may be obtained by writing to the Department of Food and Resource Economics, University of Florida, Gainesville, Florida, 32601, U.S.A.

APPENDIX B

ESTIMATED PRODUCTION FUNCTIONS

Table B-1.--Paddy Production Function

$R^2 = 0.85$ Degrees of Freedom = 55			$\bar{R}^2 = 0.739$ Constant Term = 26.857	
Independent Variable Number	Description	Unit	Regression Coefficent	Mean
Miscellaneous				
1	Size of farm	Acre	0.136	7.787
2	Size of farm, squared	----	-0.00311	
3	Dummy: Market or home use	0-1	8.034***	0.277
4	Dummy: Mechanization or not	0-1	13.100***	0.125
Tillage, number of plowings in:				
5	Baisakh and Jeth	No.	-5.474	0.056
6	Asad	No.	-2.216	1.569
7	Savan and Bhadon	No.	-0.882	0.069
8	Total, squared	----	0.304	-----
Fertilization, expenditure on:				
9	Urea	Rs per Acre	-0.1157*	60.821
10	Urea, squared	----	0.00134***	-----
11	Other	Rs per Acre	-0.599*	2.555
12	Other, squared	----	0.0139***	-----
Sowing or Transplanting				
13	Labor used	Days	0.286*	14.399
14	Labor used, squared	----	-0.00336	-----
Cultivation in Savan				
15	Labor used	Days	-2.858**	3.533
16	Labor used, squared	----	0.262***	-----

Level of significance: *80 percent; **95 percent; ***99 percent.

Table B-2.--Wheat Production Function

$R^2 = 0.771$ Degrees of Freedom = 55			$\bar{R}^2 = 0.633$ Constant Term = 10.069	
Independent Variable Number	Description	Unit	Regression Coefficient	Mean
Miscellaneous				
1	Size of farm	Acre	0.931***	8.772
2	Size of farm, squared	----	-0.012*	-----
3	Dummy: Market or home use	0-1	-4.644	0.243
Tillage, number of plowings in:				
4	Asad, Savan and Bhadon	No.	3.403***	0.397
5	Kuar	No.	0.488	0.391
6	Katik and Aghan	No.	-6.550*	1.032
7	Katik and Aghan, squared	----	1.402	-----
8	Kuar times Katik and Aghan	----	1.285	-----
Fertilization, expenditure on:				
9	Urea	Rs per Acre	0.069	62.423
10	Urea, squared	----	-0.000122	-----
11	Other	Rs per Acre	-0.2181	10.738
12	Other, squared	----	0.0011	-----
Sowing				
13	Dummy for Aghan	0-1	-29.482**	0.0335
14	Labor used in sowing	Days	0.835***	6.094
Irrigation, number of times in:				
15	Aghan	No.	-4.275	1.000
16	Poos	No.	-5.282	0.820
17	Magh	No.	15.620**	0.641
18	Aghan times Poos	----	20.007***	-----
19	Aghan, times Poos, times Magh	----	9.859***	-----
20	Total, squared	----	-3.769	-----
Cultivation, number of cultivations in:				
21	Aghan	No.	4.153	0.0897
22	Poos	No.	5.378**	0.1731

Level of significance: *80 percent; **95 percent; ***99 percent.

Table B-3.--Gram Production Function

	R^2 = 0.254 Degrees of Freedom = 40		$\bar{R}^2$ = 0.123 Constant Term = 23.626	
Independent Variable Number	Description	Unit	Regression Coefficient	Mean
Miscellaneous				
1	Size of farm	Acre	0.516*	5.804
2	Size of farm, squared	----	-0.013	-----
Tillage, number of plowings in:				
3	Kuar and Katik	No.	-16.477**	1.542
4	Kuar and Katik, squared	----	3.946**	-----
Irrigation, number of times in:				
5	Aghan, Poos, or Magh	No.	7.599	0.135
Harvesting				
6	Dummy: for Harvesting in Fagun or other	0-1	-5.027	0.406
Interaction				
7	Number of plowings times number of irrigations	----	3.899*	-----

Level of significance: *80 percent; **95 percent; ***99 percent.

Table B-4.--Peas Production Function

R^2 = 0.492 Degrees of Freedom = 31		$\bar{R}^2$ = 0.275 Constant Term = 15.409		
Independent Variable Number	Description	Unit	Regression Coefficient	Mean
Miscellaneous				
1	Size of farm	Acre	-0.0653	4.410
2	Size of farm, squared	----	0.0067	-----
Tillage, number of plowings in:				
3	Kuar and Katik	No.	3.586	2.439
4	Kuar and Katik, squared	----	-1.094*	-----
Manuring				
5	Dummy: for manure or none	0-1	1.344	0.927
Fertilization, expenditure on:				
6	Urea	Rs per Acre	0.0376	13.854
7	Urea, squared	----	-0.000766	-----
Irrigation, number of times in:				
8	Aghan and Poos	No.	-3.225	1.049
Harvesting				
9	Dummy: for harvesting in Fagun or other	0-1	-3.142	0.073

Level of significance: *80 percent; **95 percent; ***99 percent.

Table B-5.--Sugarcane Production Function

	$R^2 = 0.598$ Degrees of Freedom = 30		$\bar{R}^2 = 0.375$ Constant Term = 110.028	
Independent Variable Number	Description	Unit	Regression Coefficient	Mean
Miscellaneous				
1	Size of farm	Acre	79.115***	4.926
2	Size of farm, squared	----	-3.319	-----
Tillage, number of plowings in:				
3	Fagun and Chait	No.	36.490	2.163
4	Fagun and Chait, squared	No.	-9.244	-----
Fertilization, expenditure on:				
5	Urea	Rs per Acre	3.605*	89.628
6	Urea, squared	----	-0.018	-----
7	Other	Rs per Acre	2.984*	167.628
8	Other, squared	----	-0.0065*	-----
Irrigation, number of times in:				
9	Chait, Baisakh, Jeth, and Asad	No.	-5.863	2.744
10	Chait, Baisakh, Jeth, and Asad, squared	----	5.084	-----
Cultivation, labor used in:				
11	Chait, Baisakh, Jeth, and Asad	Days per Acre	0.587	55.556
12	Chait, Baisakh, Jeth, and Asad, squared	----	-0.0065	-----

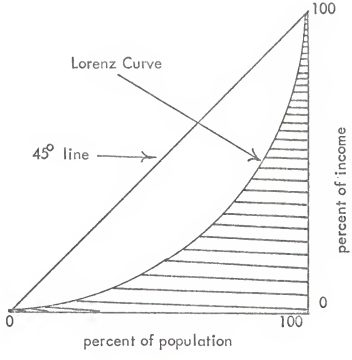
Level of significance: *80 percent; **95 percent; ***99 percent.

APPENDIX C

CONSTRUCTION OF THE EQUALITY INDEX

A Lorenz curve can be constructed by plotting the cumulative percentage of income earned against the cumulative percentage of population. The area between the Lorenz curve and the two axis' divided by the area between the 45 degree line and the two axis gives the index of equality; i.e., the shaded area divided by the area of the triangle in diagram below. An increase in the shaded area to the right of the Lorenz curve, indicates a more equal distribution of income.

If the income distribution becomes equal, then the shaded area would occupy the entire area of the triangle and the equality index would be equal to one. Equality index is also the Gini index of inequality subtracted from one.



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Bharat Jhunjhunwala was born on October 11, 1949 at Kanpur. He obtained the Bachelor of Science degree from Kanpur University in 1969, and the degree of Master of Science in Agriculture from the University of Florida in 1971, where he continued his program toward the degree of Doctor of Philosophy. He joined the Union for Radical Political Economics in 1970 and has continued to be in that organization. He has never lived in a village, nor has he ever experienced malnutrition, hunger, poverty or unemployment.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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Graduate Research Professor of Food and Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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June 1973

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